Photogrammetry: Capturing Objects in 3 Dimensions

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Digital Arts and Humanities Workshop Series – Fall 2017

Fridays @ noon -- Scholars Commons IQ-Wall

Date	Topic	Presenter
Aug. 25	Intro to Visualization	Michael Boyles
Sep. 1	Intro to Digital Humanities	Tassie Gniady
Sep. 8	Virtual Reality	Bill Sherman
Sep. 15	Intro to R	Tassie Gniady
Sep. 22	Advanced Media	Chris Eller
Sep. 29	Augmented Reality	Chauncey Frend
Oct. 13	R for Text	Tassie Gniady
Oct. 20	Network Graphs	David Kloster
Oct. 27	R for Twitter	Tassie Gniady
Nov. 3	3D Scanning & Printing	Jeff Rogers
Nov. 10	3D Photogrammetry	Tassie Gniady
Dec. 1	IQ-Tables & Touch-Enabled Software Workflows	David Reagan

Follow along

https://iu.box.com/v/HPCphotogrammetry

What is Photogrammetry?

- Photogrammetry is...
- the science of making measurements from photographs, especially for recovering the exact positions of surface points.
- as old as modern photography, dating to the mid-19th century
- in its simplest form, determining the distance between two points that lie on a plane parallel to the image plane (a technique used frequently in aerial reconnaissance)

–Wikipedia

- Photogrammetry is a practical and cost-effective alternative to 3D scanning
- especially thanks to digital photography, powerful computing, and new image-matching algorithms
- useful to a variety of fields, from cultural heritage to paleontology to art

Methods of Capture

- **Scanning** – Advanced Visualization Lab: vishelp@iu.edu]
  - GoScan Model of Benjamin Harrison

- **Photogrammetry** – CyberDH: cyberdh@iu.edu
  - Autodesk ReMake (FREE)
  - Agisoft Photoscan on Karst Desktop

How Do Other People See My Work?

3D Preview Capability

Youtube

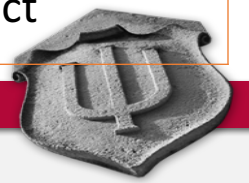
Sketchfab

ReMake Gallery

Open Source X3D Viewer

Stages of Photogrammetry

Stage	Purpose	Inputs	Outputs
Photo (Camera) Alignment	Search for common points/features and match them. Compute camera positions by building a spatial model of those common points.	Photographs (preferably with EXIF metadata and 60-80% overlap)	Camera positions & Sparse point cloud (Sparse cloud is only used for masking background)
Build Dense Point Cloud	Based on the camera model, calculate the X,Y,Z coordinates of all points in the photographs.	Photographs and camera positions	Dense Point Cloud
Build a Mesh Model	Turn the points into surfaces.	Point cloud	3D polygonal mesh
Texture Generation	Add texture and color to the surfaces.	3D mesh	Textured 3D model of the object



Where We're Headed

We will:

- compare photos taken with a Nikon 5300 DSLR camera to those taken with an iPad
- lay out the ideal settings for a DSLR camera (some apps for smart phones also allow the user to "control" some settings)
- lay out the ideal settings for conducting a photo shoot
- go through the process of uploading photos, getting back a model, and doing some basic clean up on that model

Do I really need a fancy camera?

It depends…

- If you are doing research-quality work, then you should make the investment. Good DSLRs start around $500. Always shoot in RAW, as you have more post-processing options.
- If you want to empower a group of people quickly, a smart phone or tablet is fine.

iPad

DSLR camera

Camera Settings

- Aperture setting is a balancing act between maximizing depth of field with smaller aperture size (larger f-stop number) and decreasing sharpness due to diffraction with smaller aperture. Between f/8 and f/16 will usually work.
- Make sure your lens is at a fixed focal length—if a zoom lens, retract or extend all the way. You might even tape it.
- Use the lowest possible ISO that yields good exposure, as higher ISOs introduce more noise into the photo, which makes pixel matching more difficult for the software.
    - The lower the ISO, the slower your camera responds to light, so consider using a remote to trigger the camera so you won't bump it when shooting

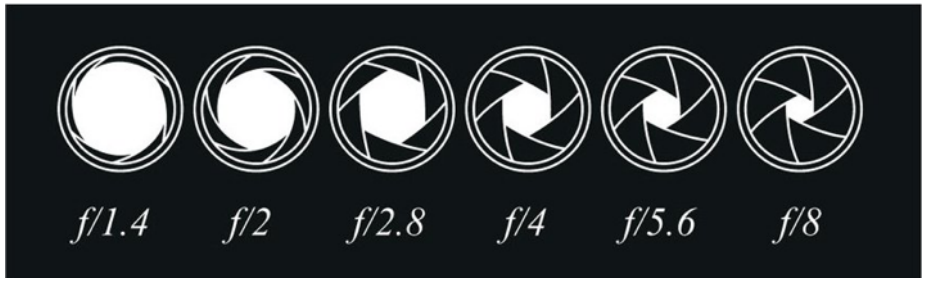


Photo cred: http://vagabond3.com/dslr-videography-basic-settings/

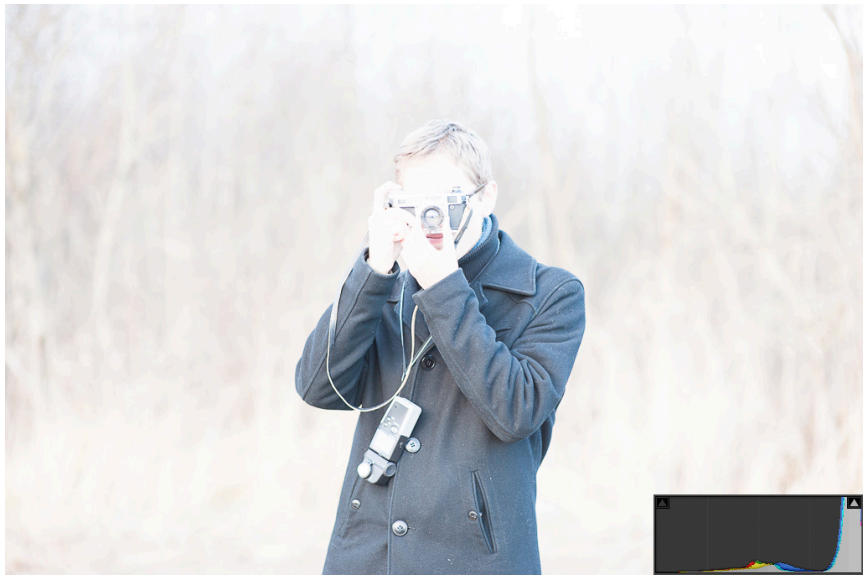
Manual vs Auto Settings

- As a camera n00b myself, I start with the camera on Auto to get initial settings, then switch it over to manual.
- Leave autofocus on—it doesn't affect the stitching and saves you (me) from many blurry pictures.
- If you are hand-holding the camera, leave motion stabilization on. If you have a tripod, turn it off.
- Take a test shot with a white balance card to make sure your metering is correct.

Histogram

- A histogram is a graphical representation of the tonal values of your image.
- If a certain portion of the histogram is “touching” either edge, it will indicate loss of detail, also called clipping.
- Underexposure

Overexposure



Goldilocks “Just Right Exposure”

All source material on this slide and the previous slide from https://photographylife.com/understanding-histograms-in-photography/

Shooting Strategies [1]

- Each shot should overlap by 50% so the software can understand how relate each picture to the next.
- Do not move the object if you are circling it (see below).
- Do not change the lighting (try to get the best lighting on the front of the object if the lighting is uneven).
- Do not change the background (i.e. do not have people in the background—they will move!).
- Do include some objects with simple geometries and colors in the background as they help the stitching software. These objects should be arranged around the subject so that every shot has at least one "helper" object in it.

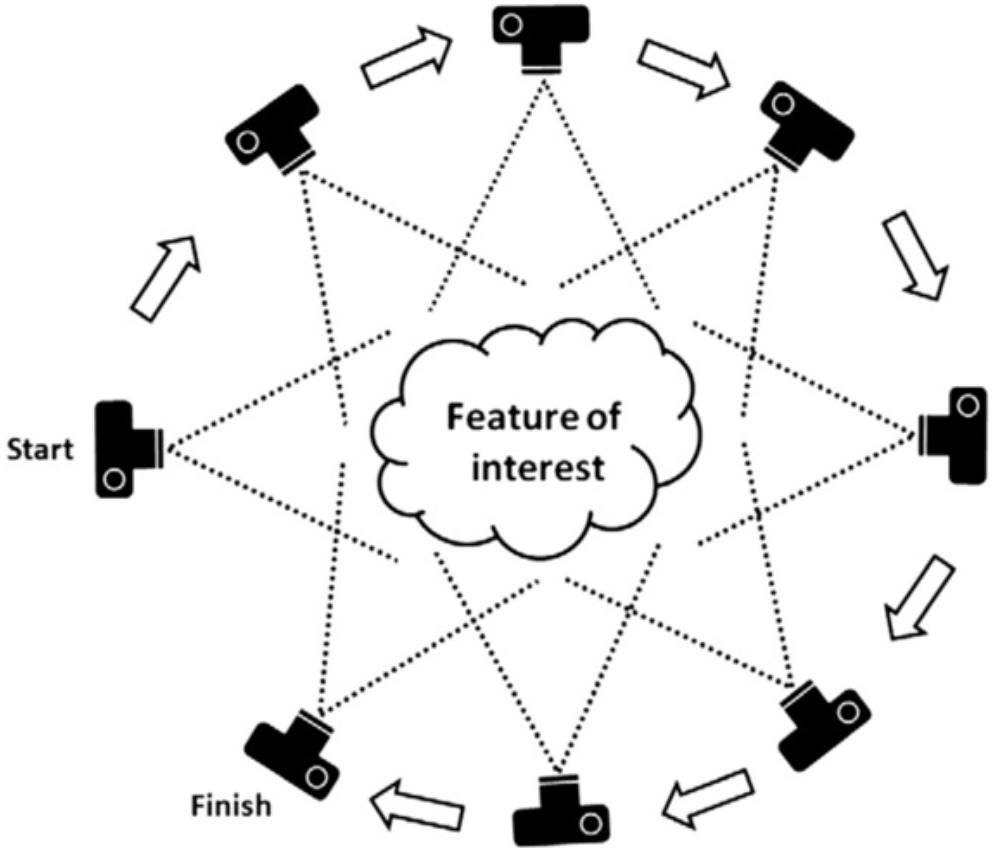


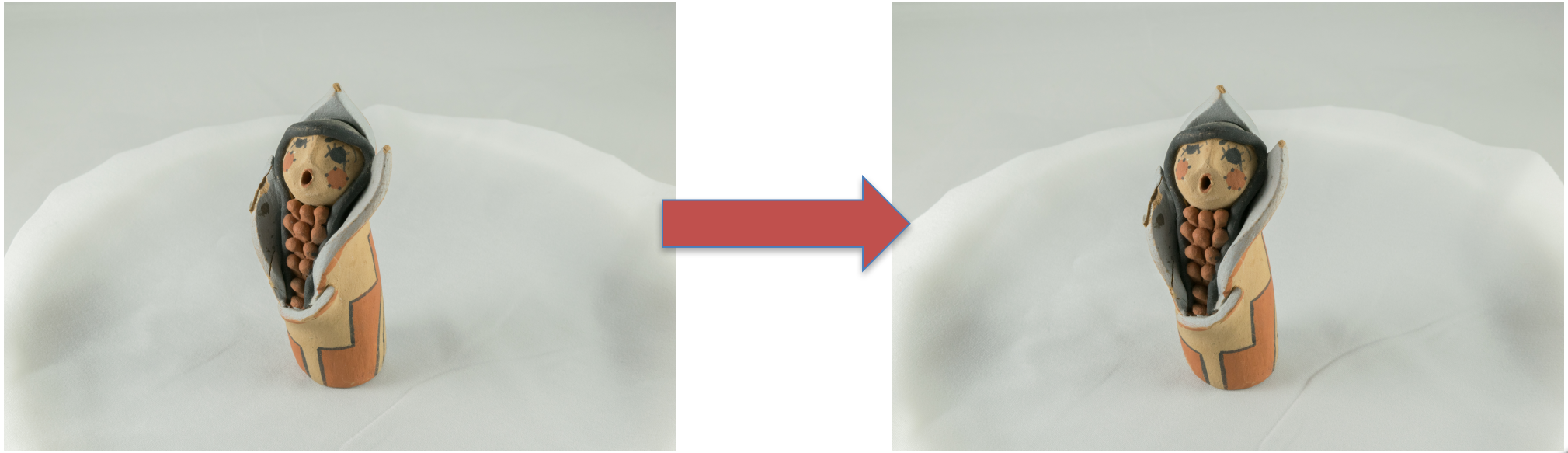
Photo cred: https://www.gislounge.com/making-3d-models-photogrammetry/

Camera Placement

https://thevirtualassist.net/capturing-reality-photogrammetry-software-interview/

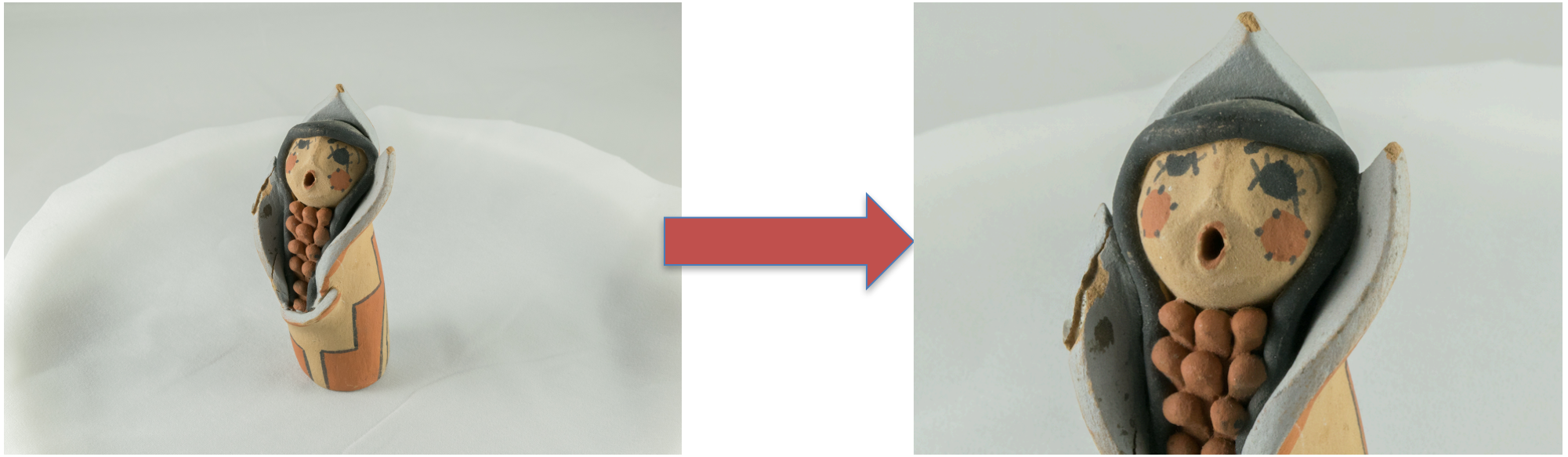
Shooting Strategies [2]

- A life-size object requires about 300 photographs taken in three passes, low, medium, and high height. It is ideal if you have a step ladder to capture the top of something that is life-sized.



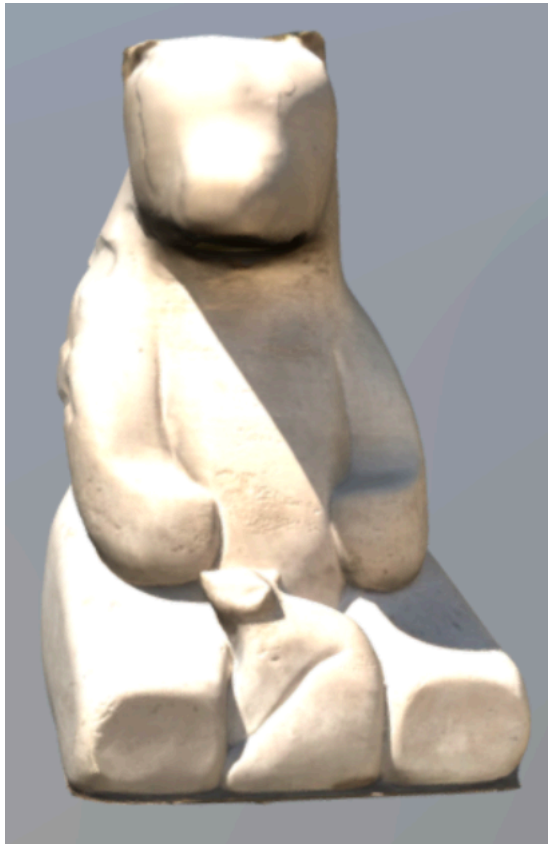
Shooting Strategies [3]

- Extra pass: details of great importance that may have been occluded in a previous pass. Simple close-ups will not work—the software does not understand them. Remember that these details must be related to the pictures before them, so as you move in keep overlapping!



Environmental Conditions

- If shooting outside, do so on a cloudy day with little to no wind. Sunlight casts shadows that are hard to process and wind may move object(s) of focus.
- If shooting inside, do so away from windows in an evenly lit room.
- It is possible to create a light box and move the object if it is important to capture all sides. You can create your own green screen with a green sheet! In this case, the background should be as uniform as possible and the object is moved to each position needed to capture all sides.



Processing Photos

- Review your photos and delete any blurry ones. The adage garbage in, garbage out is especially true in photogrammetry.
- If you have shot in RAW and have access to Lightroom, you can color correct and adjust other factors as needed.
- Export from Lightroom as JPEGs. Don't forget to have a storage plan for your original, derived, and stitched photos, though. We use Box at our University, and we recommend having a shareable, sustainable plan in place.

Stitching Photos with PhotoScan

- IU has a high performance cluster called Karst, and, unlike most HPC systems, we have a way to use it as a Desktop, not from the command line
- We have 60 licenses for parallelized stitching using PhotoScan

- Why use PhotoScan?
  - Fine grain control over the process
  - Large photosets
  - Used by many in cultural heritage

Why Use PhotoScan?

- PhotoScan is a commercial photogrammetry tool from Agisoft
- supports Windows, Mac, & Linux systems
- plus parallel computing: multicore, GPU, parallel cluster

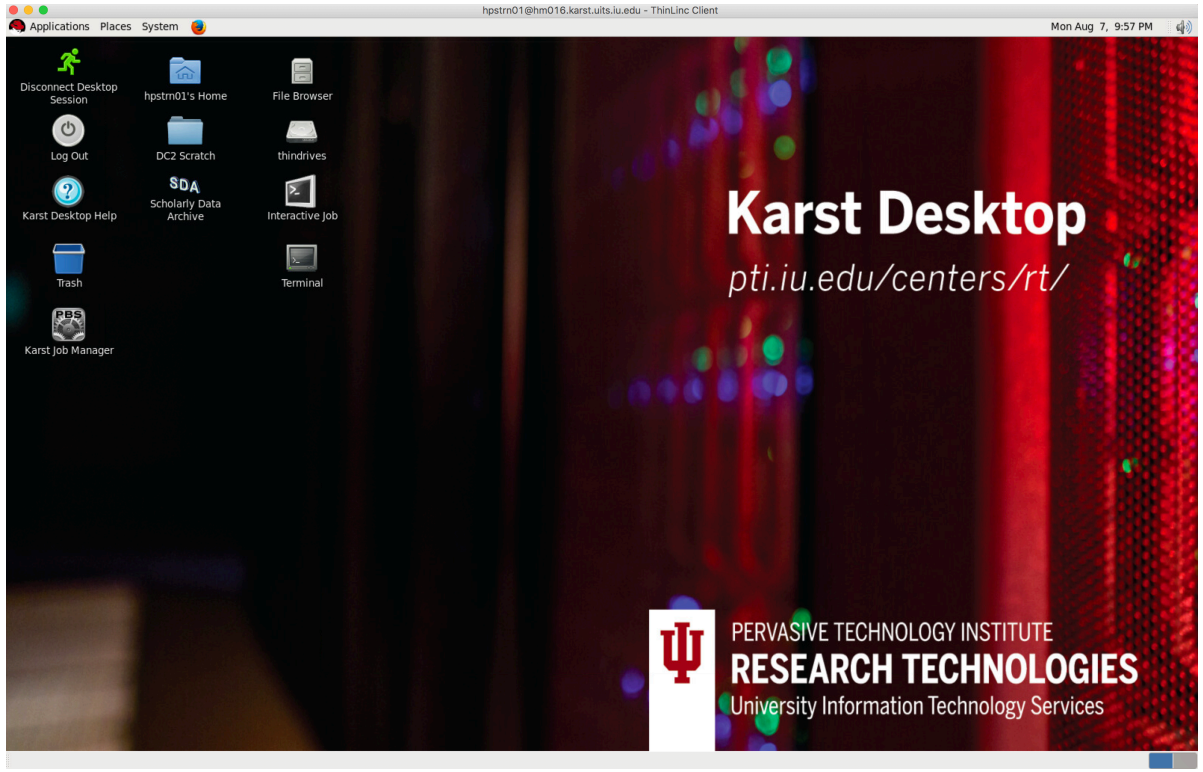
- Why use PhotoScan?
- Provides fine grain control over the process
- Scales to large photosets
- Leverage RT expertise & consultation services

- Why use PhotoScan on Karst? (IU High-Throughput system)
- unlike many HPC systems, we can use it via the desktop (interactive, on-demand) and the command-line (batch scheduler, highly parallel)
- RT provides 60 licenses, scripts, and instructions for parallelized stitching

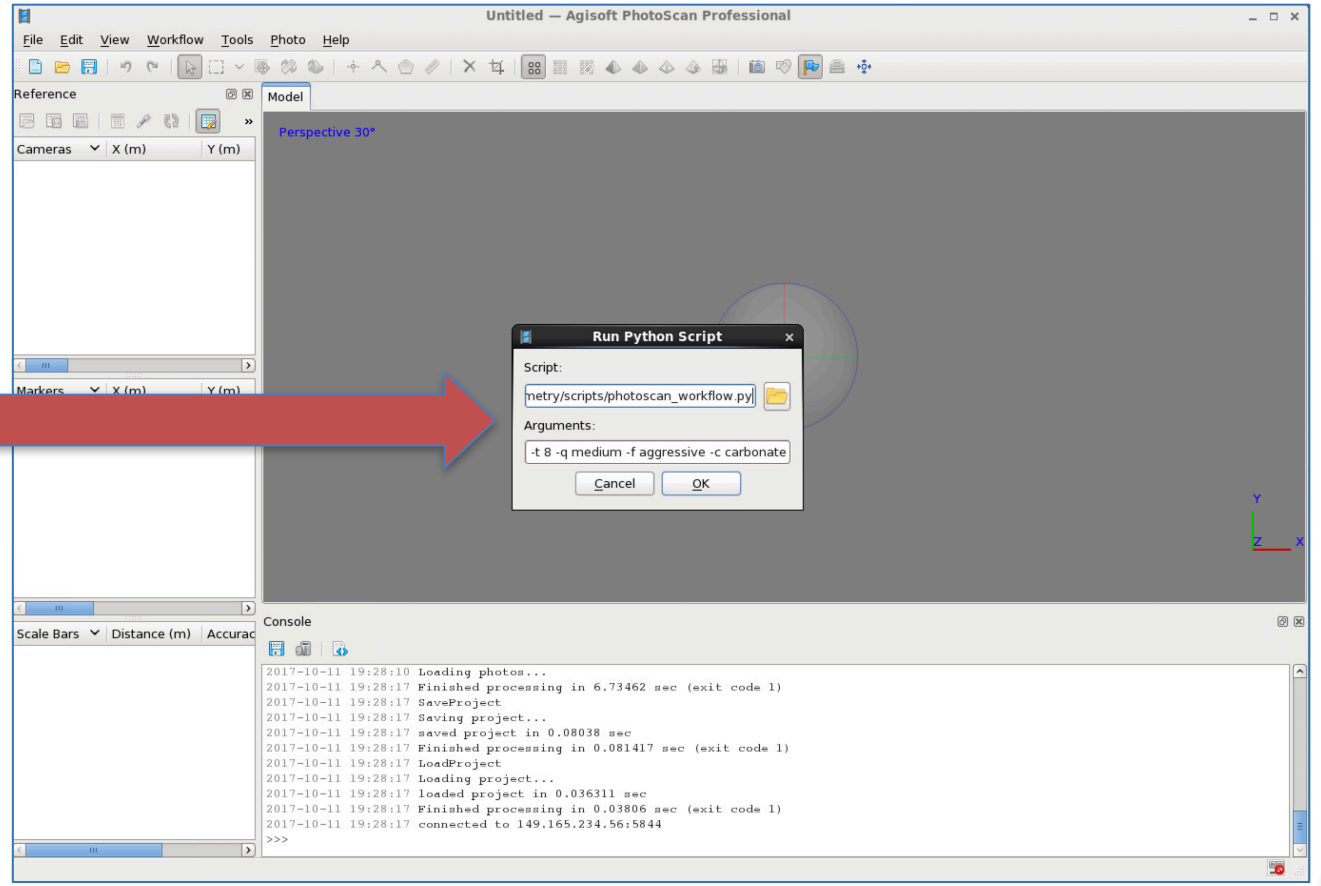
Karst Processing

1. Upload photos to photogrammetry project drive
2. Log onto Karst Desktop and align photos (in interactive mode)
3. Run script to compute dense point cloud and mesh (in batch mode)
4. System sends emails about the job as it progresses
5. When finished, edit mesh in PhotoScan on Karst or download for MeshLab (free) or Zbrush (commercial)

Using PhotoScan on Karst Desktop = No Command Line!



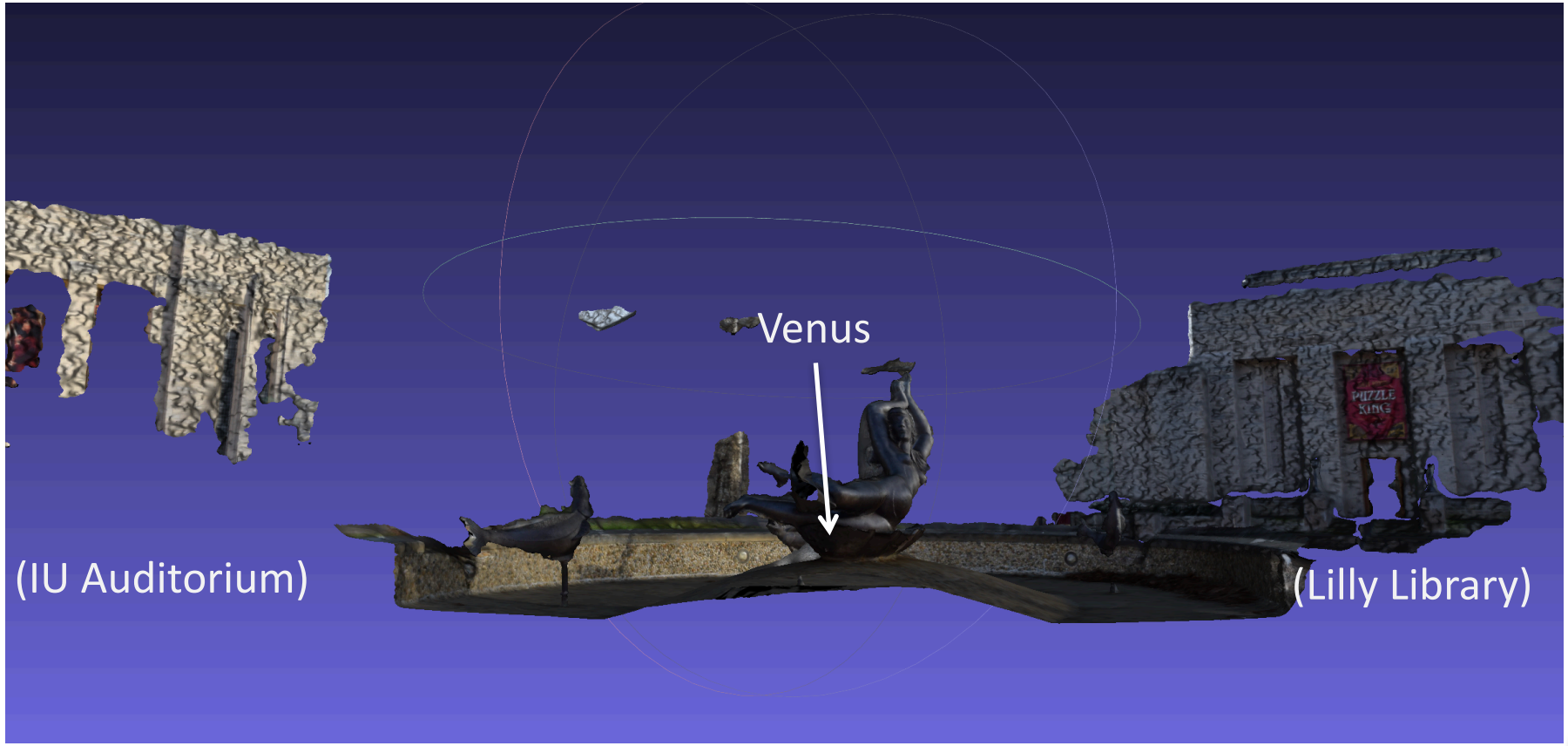
PhotoScan GUI



Invoke a script that we have created to send the job to Karst or Carbonate for processing.

Raw Results

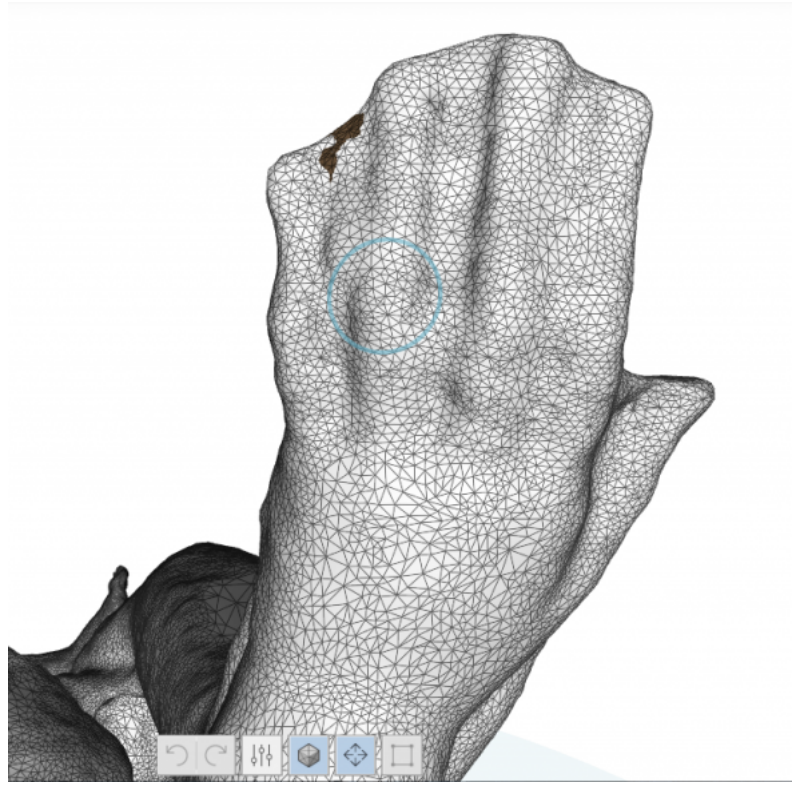
Showalter Venus before clipping and clean-up



Cleaning the Model

- Zbrush, MudBox, and Meshlab include a number of simple tools for model cleaning:
- Slice and fill
- Sculpting and smoothing
- Filling of holes and bridging of large gaps

- Caveat: Start by deleting the parts of the model you don't want! (The initial model may be very large, and this is the best way to avoid crashing editing tools.)



After of Showalter Venus

Ongoing & Future Work

- External Collaborators
  - Berkeley
  - UCLA

- Internal Collaborators
  - 3D Metadata with the libraries
  - Other potential software options: Reality Capture w/VWHL, open source alternatives

- Other systems under consideration
  - IU HPC: Carbonate, Big Red II, HPC condo nodes
  - XSEDE: Jetstream, Stampede 2
  - Cloud: Public or private cloud (UITS/II) cluster

More Information

The CyberDH team can advise you on HPC photogrammetry at your university. Get in touch!

Contact:
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Login Info

HPC Usage instructions:

https://iu.box.com/v/HPCphotogrammetryPDF